



(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

14.07.1998 Bulletin 1998/28

(51) Int Cl. C21D 1/76

(21) Application number: 99300009.0

(22) Date of filing: 04.01.1999

(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE

Designated Extension States:

AL LT LV MK RO SI

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(30) Priority: 12.01.1998 GB 9800628

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(64) Furnace atmosphere dew point control

(57) The control of furnace atmosphere dew point in which a side stream of the hydrogen supply to the furnace is withdrawn, humidified by reaction with a me-

tered supply of oxygen-containing gas and then introduced into the furnace, preferably at the hot zone(s) thereof.

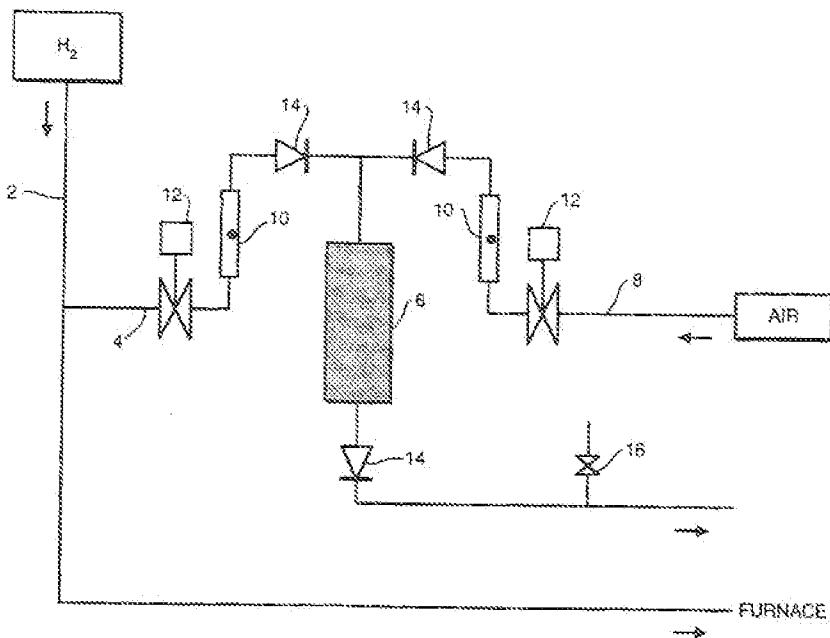


FIG.1

## Description

[0001] This invention relates to the control of the dew point in a protective atmosphere within a furnace, and in particular a furnace atmosphere containing hydrogen.

[0002] It is common for furnaces to be provided with a protective atmosphere, for example to prevent oxidation adversely affecting the processes within the furnace. For example, a Vertical Bright Annealer (VBA) furnace, used to anneal stainless steel sheet or strip, operates with a protective atmosphere having a composition of about 75% hydrogen and 25% nitrogen. Such an atmosphere is highly reducing and very dry. In fact, the furnace dew point can attain minus 70°C or even drier. At such dryness levels there is a strong tendency toward the formation of a white powder deposit, particularly in the cooler regions of the furnace (for example the jet coolers), and these deposits inhibit the operating efficiency of the furnace. In order to remove the powder build-up it is usually necessary to shut down the furnace, which is time consuming and inefficient.

[0003] It has been discovered that the problem of powder deposition can be alleviated by controlling the furnace dew point. In particular, in a VBA furnace such as that described above, maintaining the hot zone dew point between about minus 40°C and minus 55°C has been shown to minimise the formation and deposition of white powder. The volume of water typically required to promote a dew point change from minus 70°C to minus 55°C is 1.3ml per 100m<sup>3</sup> of total furnace atmosphere flow. A method of humidifying the furnace atmosphere, to effect the necessary increase in furnace dew point, employs the introduction of water mist, or vapour, into the protective atmosphere gas stream supplied to the furnace. Such an arrangement has been reasonably successful in curbing an excessively low dew point, but is inaccurate and unable to maintain a controlled dew point. In practice, a lubrication misting unit having a water-filled reservoir is employed, the water mist being introduced from the unit into the furnace atmosphere gas stream. Such arrangements are also dependent on the operator remembering to refill the unit with water.

[0004] An improved method of controlling a furnace atmosphere dew point (wherein, in use, the furnace is supplied with an atmosphere consisting at least in part of hydrogen) comprises withdrawing at least part of the flow of hydrogen being supplied to the furnace, reacting the withdrawn hydrogen with an oxygen-containing gas so as to produce a gas mixture consisting of an oxygen-free product gas, residual hydrogen and water, and directing the gas mixture into the atmosphere supplied to the furnace so as to maintain the water vapour content of the furnace atmosphere within a predetermined range.

[0005] Such an arrangement enables the provision of a controllable, automatic method of dew point adjustment of the furnace atmosphere, and enables the dew point to be accurately controlled and maintained within

a given range.

[0006] The water vapour-containing gas mixture may be directed in to the flow of hydrogen prior to its introduction in to the furnace or, more preferably, may be directed in to the hot zone(s) of the furnace. In either case, the water vapour content can be accurately controlled, however the latter arrangement advantageously humidifies only a proportion of the total atmosphere flow in to the furnace and hence is inherently more efficient than the prior art methods in which the total atmosphere flow in to the furnace is humidified.

[0007] In the manufacture of industrial gases it is common to use catalytic gas deoxygenation ("deoxo") units. In operation, such units cause any oxygen present in the feed gas to react with hydrogen to form water; the resulting output from such a deoxo unit is a combination of oxygen-free product gas, residual hydrogen and water. Such deoxo units can profitably be used in the present invention to humidify a furnace atmosphere, being employed primarily as "water generators". These deoxo units are highly efficient, and therefore water output can be precisely controlled; accordingly, the installation of a catalytic deoxo unit in the hydrogen pipeline serving the furnace enables the provision of a highly controllable method of dew point adjustment of the furnace atmosphere.

Those skilled in the art will appreciate that the addition of a dew point sensing means and a suitable control device, such as a suitably programmed microprocessor, will produce a simple, inexpensive yet effective automatic dew point control system. Commercial deoxo units are also advantageous as they are completely self-contained, and do not require any external services or attention for their operation.

[0008] The invention will now be described by way of example and with reference to the accompanying drawing, Figure 1, which is a schematic diagram of an apparatus for humidifying the atmosphere supplied to a VBA furnace, and thus for controlling the dew point thereof.

[0009] In the apparatus of Figure 1, a proportion of the hydrogen feed passing along supply line 2 to the VBA furnace is diverted along line 4 leading to a catalytic gas deoxygenation unit 6 thereto react with the oxygen in a supply of air passing along line 8 (the air typically being provided by a compressed air system, as cylinder gas or from a small compressor). Flow meters 10 measure the flows of hydrogen and air into the deoxo unit 6, these flows being controlled by regulator valves 12. Check valves 14 prevent back flows. A valved off-take 16 is provided for sampling the gas supplied by the deoxo unit 6 for measuring the dew point.

[0010] In practice, hydrogen is supplied to the furnace atmosphere control system at high pressure (about 8bar) and the hydrogen withdrawn along line 4 is regulated to a lower pressure before passage through the deoxo unit 6. Passage through the deoxo unit results in a chemical combination of a proportion of the hydrogen and all of the oxygen in the air supply to the deoxo unit 6 in the ratio 2 to 1 by volume to form water vapour. The

outlet gases (hydrogen, water vapour and a small amount of nitrogen) is reintroduced back into the furnace atmosphere at a suitable low pressure (less than 8bar) location, such as into the main hydrogen feed immediately prior to its ingress into the furnace, or into the furnace itself.

[0011] The dew point 'shift' necessary to obtain dew point temperature levels within the range minus 40°C to minus 55°C is relatively minor. A water vapour content within the above-mentioned VBA furnace atmosphere of 128ppm is equivalent to the higher dew point condition while 22ppm represents the drier condition. As the required water vapour levels are so low it is possible to accomplish the necessary humidification of the furnace atmosphere by treating only a small sidestream of the feed hydrogen supply to the furnace. Accordingly, up to about 3m³/hr of hydrogen (about 2.0% of the total hydrogen flow) is withdrawn for humidification.

[0012] As will be appreciated by those skilled in the art, the amount of water vapour produced can be controlled with great accuracy because the input flow rates of both hydrogen and air to the deoxo unit can be very accurately measured and controlled. Moreover, deoxo units are highly efficient in operation, and the size and hence expense of deoxo unit necessary could be reduced if it were desired to humidify the atmosphere in the furnace hot zone(s) only.

#### Claims

1. A method of controlling a furnace atmosphere dew point wherein, in use, the furnace is supplied with an atmosphere consisting at least in part of hydrogen, the method comprising withdrawing at least part of the flow of hydrogen being supplied to the furnace, reacting the withdrawn hydrogen with an oxygen-containing gas so as to produce a gas mixture consisting of an oxygen-free product gas, residual hydrogen and water, and directing the gas mixture into the atmosphere supplied to the furnace so as to maintain the water vapour content of the furnace atmosphere within a predetermined range. 20
2. A method as claimed in Claim 1 comprising controlling the amount of hydrogen withdrawn and/or the amount of oxygen-containing gas reacted therewith in order to maintain the predetermined water vapour content range between about 10ppm and about 200ppm, preferably between about 22ppm and about 128ppm. 25
3. A method as claimed in Claim 2 comprising monitoring the temperature and/or dew point of the furnace atmosphere and controlling the amount(s) of hydrogen withdrawn and/or oxygen-rich gas supplied for reaction accordingly. 30
4. A method as claimed in Claim 1, Claim 2 or Claim 3 wherein the gas mixture is directed into the flow of hydrogen prior to its introduction into the furnace. 35
5. A method as claimed in Claim 1, Claim 2 or Claim 3 wherein the gas mixture is directed into the hot zones(s) of the furnace. 40
6. A method as claimed in any preceding Claim wherein the oxygen-containing gas is air. 45
7. Apparatus for controlling a furnace atmosphere dew point wherein, in use the furnace is supplied with an atmosphere consisting at least in part of hydrogen, the apparatus comprising means for withdrawing at least part of the flow of hydrogen being supplied to the furnace, means for supplying an oxygen-containing gas, means for reacting the withdrawn hydrogen with the oxygen-containing gas to produce a gas mixture comprising oxygen-free product gas, residual hydrogen and water and means to direct the gas mixture into the furnace, means being provided to control the amount(s) of hydrogen withdrawn and/or of oxygen-containing gas so as to maintain the amount of water vapour produced, and hence the water vapour content of the furnace atmosphere, within a predetermined range. 50
8. Apparatus as claimed in Claim 7 wherein the reacting means comprises a catalytic gas deoxygenation unit. 55

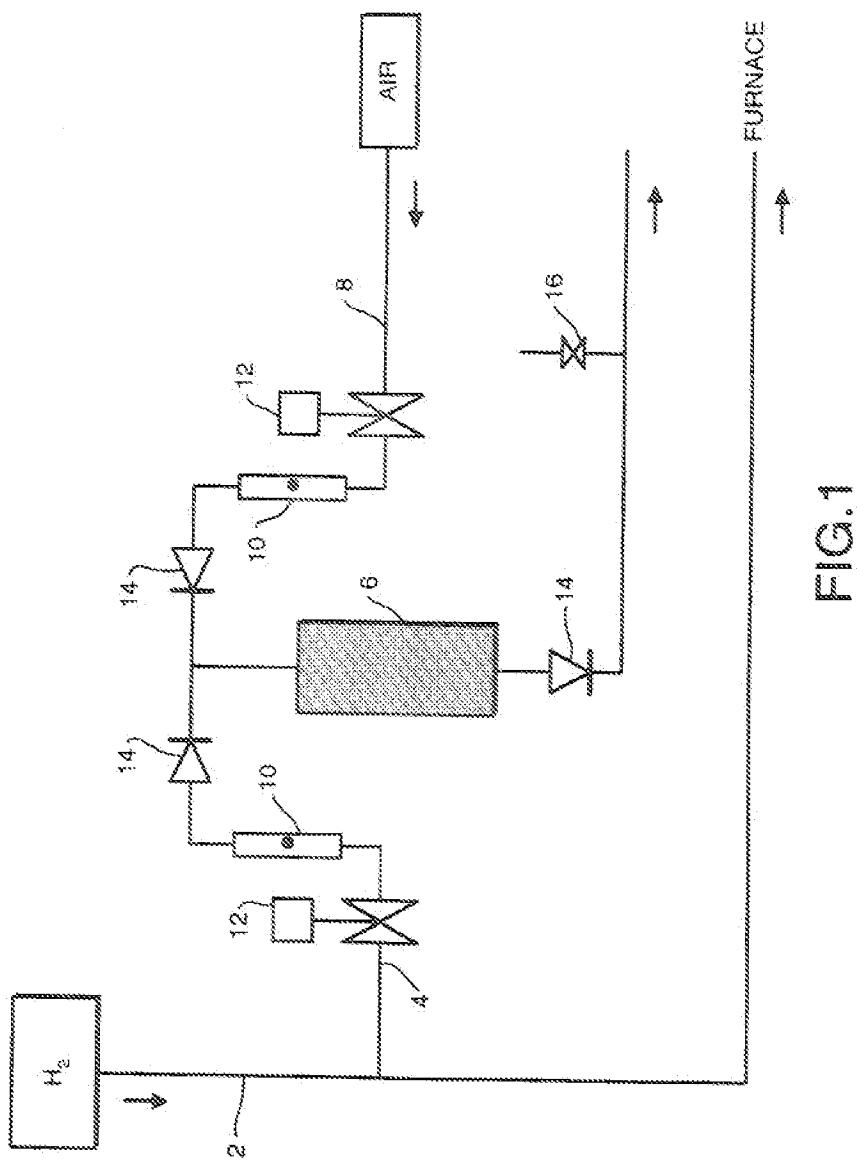


FIG. 1



## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (if applicable)
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			C21B
The present search report has been drawn up for all claims.			
Place of search		Date of completion of the search	Examiner
THE HAGUE		29 April 1999	Mallet, G
CATEGORY OF CITED DOCUMENTS			
X	particularly relevant	T : theory or principle underlying the invention	
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ANNEX TO THE EUROPEAN SEARCH REPORT  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EPO file on  
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For more details about this annex, see Official Journal of the European Patent Office, No. 16/82.